BI-TRAN 6

COMPUTER EDUCATION:

An answer to the challenge!

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One of the most powerful tools man has ever devised is the electronic computer. Its ever-enlarging contribution to the advancement of the human race has prompted contemporary historians to name this last half of the twentieth century, "the beginning of the computer age."

This brochure has been prepared by the Educational Services Department of Fabri-Tek Incorporated to pose some of the questions currently faced by educators and to suggest an answer to the questions. Fabri-Tek is intimately involved with the computer industry as a leading supplier of the computer's "heart." That heart is the computer's memory system, without which no computer can function.

Fabri-Tek has combined its scientific knowledge with the experience of prominent educators to answer one of the most vital challenges of our time, education for the computer age.

Are computers really that important to us?

In 1964 there were almost 25,000 computer installations in this country with another 11,000 on order. This represents an investment of about $6 billion. In 1970, a predicted 52,000 computer systems will be in use, representing close to $12 billion invested. Investment in computers is now rising at a rate of $2 billion per year. By 1970 almost half a million people will be operating, analyzing, programming and maintaining computers. Hundreds of thousands of people will be building them. The lives of every single man, woman, and child will be directly affected by the work done by computers.

Today, virtually every cent of our income – from paycheck to taxes – is processed by computers. Our national defense is vitally dependent upon computers. Our communications systems are becoming completely computerized. Our government, from Federal down to county, could not handle its vast responsibilities without computers. Even the concordance of the Bible used in our seminaries is the result of computer technology. Tomorrow, highly sophisticated medical diagnosis will be aided by computers.

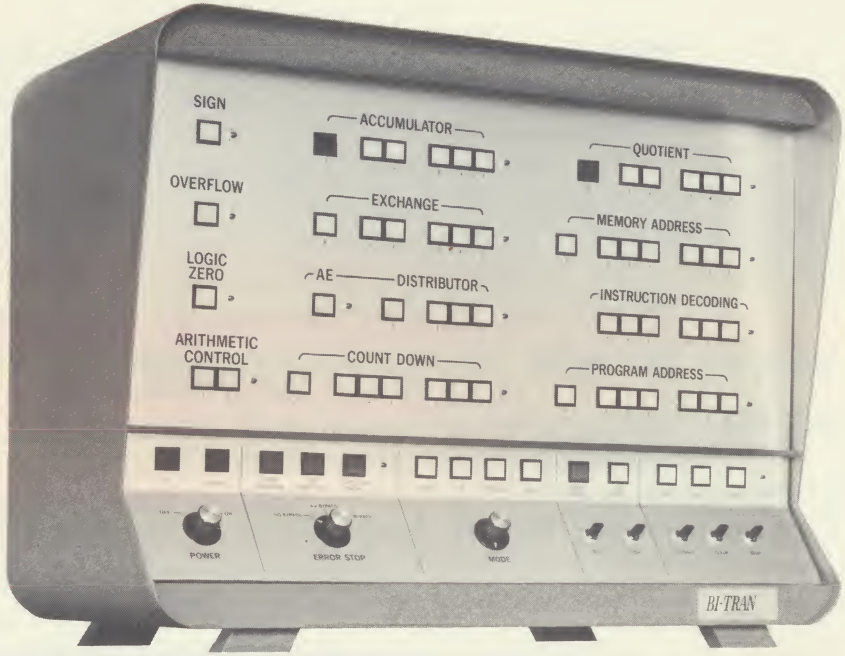
The computer will touch every vital part of our lives. Hopefully, it will free our minds and bodies from mundane, repetitive tasks to allow greater freedom of thought and recreation.

What is the responsibility of the educator today?

Everyone whose responsibility is to teach is an educator. That responsibility may be teaching basic knowledge in secondary schools, it may be technical training in vocational schools, or it may be training or retraining in industry. In all cases, the responsibility is to prepare individuals for useful, productive, interesting, and exciting lives in their changing environment.

How to start!

Teaching computer science is not like teaching such skills as typing, comptometer operation, or bookkeeping. It is not like teaching the disciplines of chemistry, physics, or electronics. It is more like teaching a new language, a language with symbols, rules, and vocabulary which involve basic thinking processes. To teach such a broad subject, blackboards, lectures, and textbooks are not enough. Computer science is not only the understanding of the tool, but the confidence in one's ability to use it. Just as you need a bicycle to teach bicycle riding, you ought to have a computer to teach computer science. Preferably, such a computer would be one designed exclusively for teaching, simple enough to start with basics, yet complicated enough to duplicate many real situations. Here's where the Fabri-Tek educational system starts, with the Bi-Tran Six digital trainer.



The teaching philosophy of the BI-TRAN SIX

The Bi-Tran Six is an inexpensive computer which has been designed exclusively for teaching computer science. It is *not* a cheap version of a full-scale, working computer, and it is *not* a laboratory mock-up which merely simulates the operation of a computer. There is nothing like it currently available to the teacher. Essentially, the Bi-Tran Six is a self-motivating, functional "textbook" which is used to transmit knowledge of computer science to the student through sight, touch, and logical thought.

What can be taught with the BI-TRAN SIX?

The BI-TRAN SIX is used to teach the basic language of computers, how they are logically organized, what can be expected of them, how they are operated, what makes them function, how they are designed, and how to keep them in operation. Because the BI-TRAN SIX is such a versatile training device, it can be used at any grade level from secondary schools through college, with each of the above subjects expanded according to the learning ability of the students.

COURSE MATERIAL

Course material is available according to your teaching circumstance. Teacher's manuals, student's workbooks, and operation manuals are prepared by McGraw-Hill in cooperation with the Fabri-Tek Educational Services Department.

The BI-TRAN SIX digital trainer as an instructional tool

Computers are being used today at all secondary grade levels as instructional tools to help motivate students and reinforce classroom training in mathematics. The BI-TRAN SIX is an ideal tool for use in programs which will:

- Demonstrate mathematical concepts
- Provide a laboratory environment in which students can put into practice the mathematics that they are learning in the classroom.

In programs in which computers are used as instructional aids, a number of benefits have been identified. Some of these are listed below.

Motivation. Use of computers provides strong motivation for students to apply mathematical training and acquire *more* mathematical knowledge. The computer has proved to be highly successful in inspiring the under-achieving student.

Experience in problem-solving. In order to solve a problem on a computer, a student must do a complete problem analysis and develop a systematic problem-solving procedure. In doing this, he usually develops a procedure that will solve all problems in a given *class* of problems. Hence, he gains insight into the structure and meaning of mathematics.

Introduction to a commonly used tool in mathematics, engineering, and science. The computer is widely used by mathematicians, engineers and physical scientists. An early introduction to the use of this powerful tool seems appropriate for technologically-oriented students. Furthermore, the use of computers is increasing daily in other fields such as social science, political science, economics, business.

Experience in technical communication. Use of a computer forces the student to be precise, correct, and unambiguous in a problem and the solution of the problem. If students are required to provide adequate documentation of their computer projects, they will receive valuable experience in technical communication.

Teaching mathematics with the BI-TRAN SIX— Three of the many mathematical topics for which the BI-TRAN SIX can be used as an instructional aid are numeration systems, the function concept, and finding solution sets of equations.

Numeration Systems – In many mathematics programs, junior high students are introduced to numeration systems using bases other than ten. This is an ideal place to introduce computer-oriented concepts. Demonstration of binary (base 2) and octal (base 8) arithmetic on an actual computer is ideal motivation for the study of numeration systems. During this study, the BI-TRAN SIX serves as a demonstrator for putting the new knowledge to practical use.

Function Concept – In introducing the function concept, many mathematics texts employ the idea of a "function machine." In this sense, the BI-TRAN SIX is a function machine that can be seen, touched, and used! This important area in mathematics is one in which the computer can be most effective.

Problem Solving – The determination of solution sets of equations and systems of equations is one of the largest and most important areas of secondary mathematics. The use of the BI-TRAN SIX focuses attention on the development of general procedures (algorithms) for the solution of a class of problems. The trainer becomes a tool for testing a procedure developed by a student to solve a class of problems.

The BI-TRAN SIX as a progressive trainer

Without physical alteration, the BI-TRAN SIX teaches any phase of computer science related to the particular course content. For beginning courses, the trainer is ideal for demonstrating the usefulness of two basic numeration systems, binary (base 2) and octal (base 8). As course material becomes more comprehensive, the BI-TRAN SIX is an ideal demonstrator to prove out basic flow-charting as illustrated below. Then, for higher grade levels, the trainer provides every necessary function to show the mathematics of computer organization and fundamental programming techniques. Finally, the trainer's design makes it superbly adapted to computer electronics education, from basic circuit design to the complexities of computer maintenance.

From the basic to the complex, using the BI-TRAN SIX

An introductory computer science course could include the following topics in about 45 class hours:

1. History of computers, need for computers.
2. Numeration systems – binary and octal arithmetic
3. General description of a computer – specific discussions of computer components (input, output, arithmetic unit, memory control)
4. Analysis of problems, construction of algorithms, flow charting
5. Computer programming – machine language, symbolic languages, compilers
6. Applications of computers – e.g., satellite tracking, language translation, information retrieval, simulation, scientific data processing, etc.

FOR THE ADVANCED STUDENT

The BI-TRAN SIX can be used to demonstrate a variety of topics:

COMPUTER ORGANIZATION. Detailed study of memory, arithmetic, and control.

APPLICATION OF ARITHMETIC ALGORITHMS. Magnitude and sign arithmetic. Parallel additive binary techniques.

BOOLEAN ALGEBRA.

LOGIC DESIGN. Complementing techniques. Decoder design. Overflow concepts. Techniques for shift, multiply, and divide. Sequencing.

COMPUTER THEORY FOR THE TECHNICIAN

The technician's status is constantly rising in the computer industry. But he is a new kind of technician, and demand is also rising for a broader kind of vocational education to produce him.

Educational emphasis is increasingly placed on the theory behind all computers, not just the specific aspects of one model. To succeed in the computer industry a man must develop the ability to translate his knowledge of basic theory from any one computer to another.

And there is a great deal of theory to learn. The new kind of maintenance technician for example, must understand the basic concepts of programming, computer organization, and logic design, as well as circuit design. To learn all this theory quickly and well, he needs to see its application demonstrated in actual practice. That is where the BI-TRAN SIX fits in. It is a training computer – designed specifically to demonstrate all aspects of basic computer theory. Its components are arranged not for high speed or large capacity, not for maximum utilization of hardware or space, but for the student's easy visualization of their interrelationships.

FOR THE TECHNOLOGY TEACHER

"Designed-for-education" features make the BI-TRAN SIX the ideal training tool in every area of basic computer theory.

PROGRAMMING The computer is easy to operate. Students can write simple programs for it the first day of class.

COMPUTER ORGANIZATION The eight extendable logic-circuit boards are arranged by function. The teacher can analyze any particular function to any depth he chooses.

BOOLEAN ALGEBRA The student can relate the theory to the actual logic design.

COMPUTER LOGIC A variety of techniques can be demonstrated: positive and negative AND/OR logic, exclusive OR logic, decoding, complementing, and logic timing principles.

MEMORY The design of the magnetic-core memory assists the teacher in demonstrating random-access, coincident-current techniques.

CIRCUIT THEORY The teacher can demonstrate the use of inverters, sense amplifiers, timing controls, delay circuits, AND/OR circuits, etc.

MAINTENANCE PROGRAMMING AND DEBUGGING TECHNIQUES Removable transistors enable the teacher to demonstrate malfunctions and the maintenance-programming techniques for locating the trouble spots.

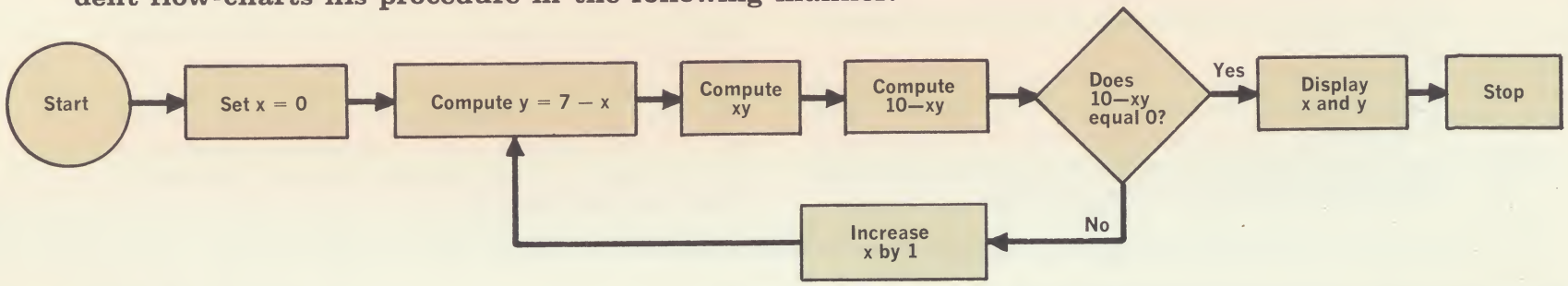
Examples of teaching computer science

TEACHING PROGRAMMING WITH THE BI-TRAN SIX

Problem: Determine two digits whose sum equals 7, and whose product equals 10. If x is one digit and y the other, the simultaneous equations are: (a) x+y=7 (b) xy=10.

You can use several methods to solve this problem. The method chosen here is the iterative technique. Choose x = 0 first, then compute y in equation (a). If the tentative solution does not satisfy equation (b), then increase x by 1 and repeat the procedure until a solution is found.

As a guide to this step-by-step solution method, the student flow-charts his procedure in the following manner.



Then the student consults the computer's instruction repertoire and writes a program, breaking down the steps of his flow chart into steps the computer can handle. He does this first in symbolic language, in this manner.

A SYMBOLIC PROGRAM				DATA		
INSTRUCTION ADDRESS	OPERATION CODE	OPERAND ADDRESS	REMARKS	DATA ADDRESS	DATA	REMARKS
A_0	LDA	X_0	Initializing phase	X_0	0	
A_1	STA	X_1	Set x = 0.	X_1	x	Set initially to 0
A_2	LDA	X_3	Compute	X_2	y	Temporary location
A_3	SUB	X_1	y = 7−x.	X_3	7	for y = 7−x.
A_4	STA	X_2		X_4	10	
A_5	MPY	X_1	Compute xy.	X_5	xy	
A_6	STQ	X_5				
A_7	LDA	X_4	Compute 10−xy.			
A_8	SUB	X_5				
A_9	NZE	A_{14}	Decision. If 10−xy = 0, go to A_{14}. Otherwise continue.			
A_{10}	LDA	X_1	Display x.			
A_{11}	SRE	5				
A_{12}	LDA	X_2	Display y and stop.			
A_{13}	STP	0				
A_{14}	RAU	X_1	Increase x by 1.			
A_{15}	UNE	A_2	Return to A_2.			

Now, all that the student needs to do is to code the program into the language of the computer, select appropriate memory addresses, and feed the program into the machine, either manually or by means of punched paper tape.

The machine-coded program would begin like this:

OPERATION CODE	OPERAND ADDRESS	
40	40	40 is listed in the instruction
60	41	repertoire as the operation code
40	43	for "load the Accumulator." So
46	41	we are loading the Accumulator

with the contents of memory address 40, where we have put a 0. 60-41 is the instruction to store in address 41 the contents of the Accumulator. We have decided that 41 will hold our variable x, set at 0 at first, though later in the program we will arrange to increase it automatically. 40-43 is the instruction to load the accumulator with the contents of memory address 43 – this is where we put the constant 7. 46-41 is the instruction to subtract the contents of address 41 – namely 0 – from the contents of the Accumulator – namely 7. The rest of the program is coded similarly.

The computer will display the answers, 2 and 5, almost instantaneously. But the thrill this gives the student is only incidental to the learning process. More useful still is the feature built into the Bi-Tran Six by which the whole program, or just its most critical parts, can be stepped off one instruction at a time. The student can analyze, with the computer's aid, the effectiveness of his programming method. He will learn more by doing this than he will by running programs automatically.

Here are 10 of the 30 versatile instructions in the BI-TRAN SIX repertoire

LDAm (Code: 40) Clear the Accumulator—A—and load it with the contents of memory address m—(m).

STAm (60) Store the contents of the Accumulator —(A)—at m.

SUBm (46) Substract (m) from (A). Difference appears in A.

MPYm (54) Multiply (A) by (m). Double-length product appears in combined Accumulator-Quotient register.

STQm (62) Store (Q) at m

NZEm (16) If (A) does not equal zero, jump to m. Otherwise continue

SREk (64) Shift (AQ) k places to the right.

STP (76) Stop the computer operation.

RAUm (50) Add to (m).

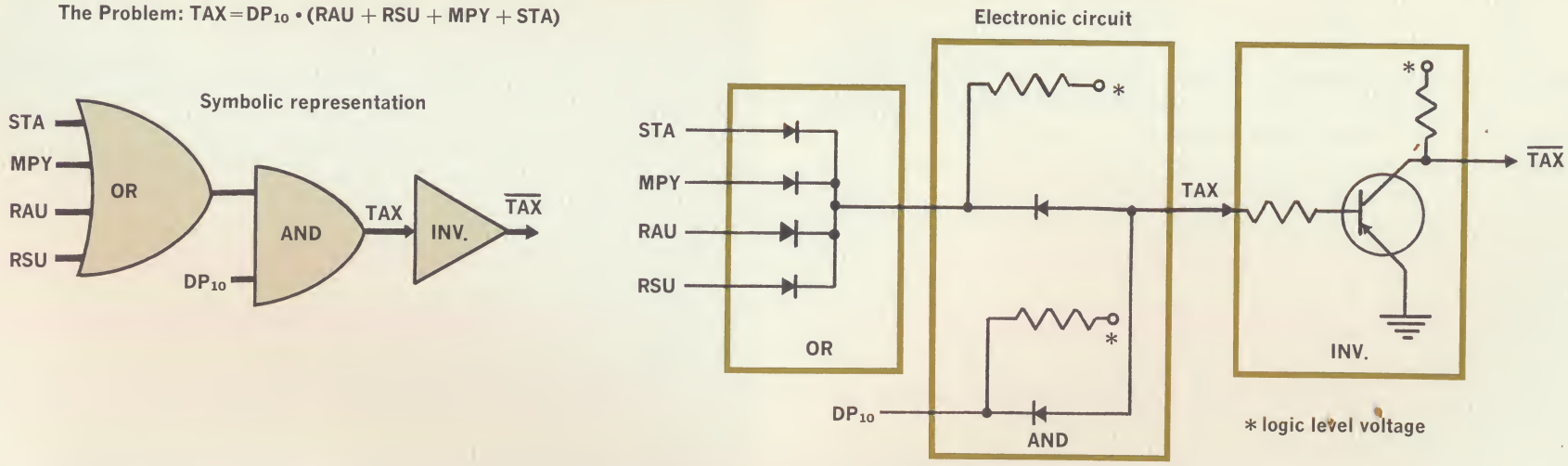
UNEm (12) Jump to address m.

Boolean Algebra

To organize the complexities of the computer's internal operation, computer designers have seized upon a century-old mathematical discipline called Boolean algebra. This is an algebra of classes, not numbers; it is intimately related to the theory of sets now being taught many grade school children. Though it looks forbidding to many novices, it is as easy to learn as arithmetic – especially if the student can see the connection between the theory and its application to the organization of an actual computer.

The BI-TRAN SIX has been designed to assist in this learning process: the example below shows the correspondence between its logic diagrams and its circuit schematics.

PROBLEM: Define the conditions necessary for transferring the contents of the Accumulator to the Exchange register if the subcommand must be performed on Distributor Pulse 10 under control of any one of the following instructions: Replace Add Unity; Replace Subtract Unity; Multiply; or Store the Contents of the Accumulator.



EQUATION:
$TAX=DP_{10} \cdot (RAU + RSU + MPY + STA)$

EXPLANATION: The Boolean equation organizes the problem by stating that data will be transferred from the Accumulator to the Exchange register if: Distributor Pulse 10 is present; and 2. if any one of the four instructions is present. The plus sign is used as the logic OR operator (set theory – "union"). The product sign is used as the logic AND operator (set theory – "intersection").

DIAGRAM EXPLANATION: The OR symbol shows that an output will result if any one of the four inputs is present. The AND symbol shows that an output will result only if all its inputs are present. Within the dotted lines is shown the combination of OR and AND logic. Circuit considerations require that an inverter be added, as the result must be changed to "NOT TAX" ($\overline{TAX}$). The actual circuit implementation of the Boolean expression is shown in the schematic at the left.

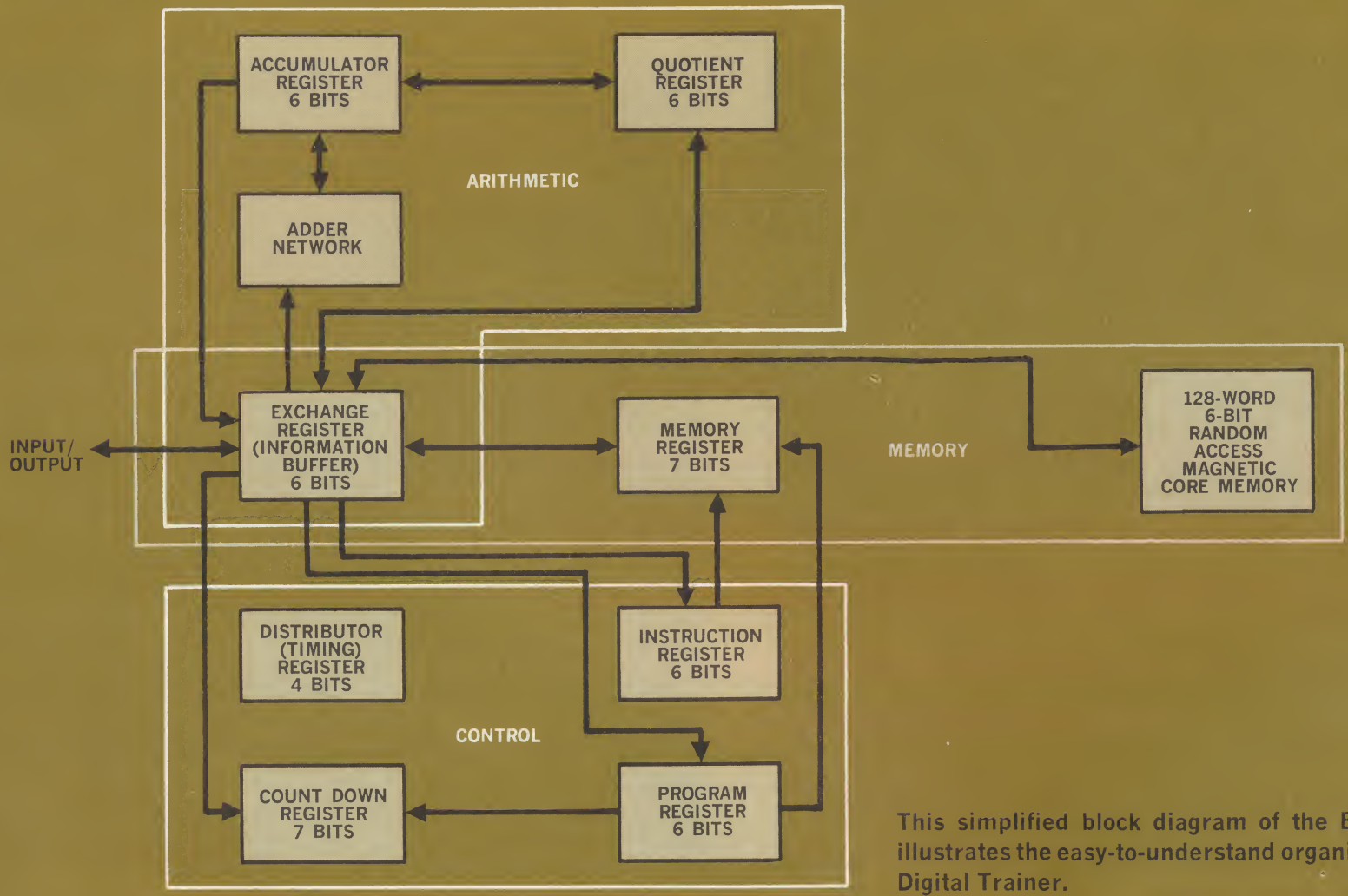
A wide variety of problems suited to every grade level can be programmed for the BI-TRAN SIX. the following list is representative:

- Perform simple business computations
- Sort or merge a set of numbers; determine the largest number or find the greatest common divisor
- Evaluate formulae
- Evaluate a polynomial
- Determine whether a number is a prime
- Determine the solution for a set of simultaneous equations
- Find the square root of a number using the Newton-Raphson iterative method
- Roots of a quadratic equation
- The value of a 2 x 2 or 3 x 3 determinant
- Matrix addition (with carefully chosen data)

Physical and electrical specifications of the BI-TRAN SIX

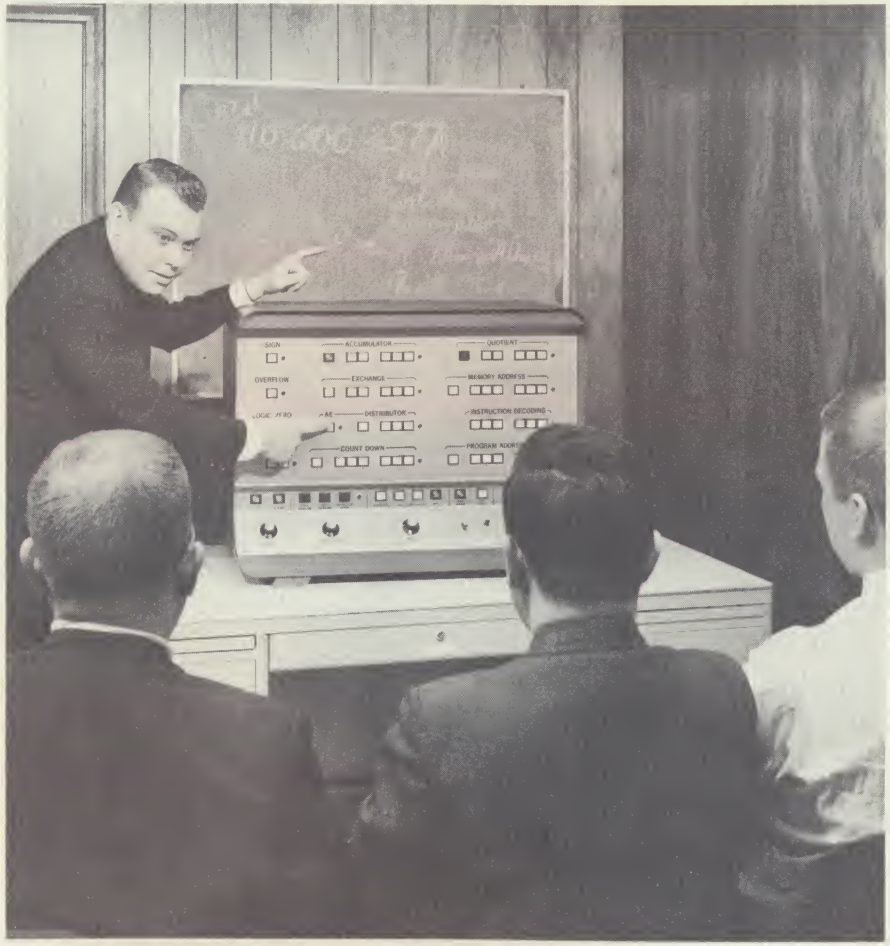
The BI-TRAN SIX is a complete operating computer. It uses the latest circuit techniques and has all-solid state components. It operates on standard 115v, 60 cycle current. It has a coincident-current core memory (typical of those used in industrial computer systems) with a capacity of 128 words of 6 bits each. Memory cycle time is 15 microseconds. Circuits are mounted on extra-large 22′ x 17′ cards which extend during operation without auxiliary extenders. Components on the cards are laid out in correspondence with the actual logic diagrams which are used in teaching the principles of computer logic. This is no "mysterious black box." All parts of the BI-TRAN SIX can be seen by the student. Circuit and logic instruction is carried on with the trainer in operation so that circuits can be observed and waveforms viewed on an oscilloscope. For complete safety, no more than 10 volts is exposed. The BI-TRAN SIX measures 31″ x 23″ x 17″ and weighs only 98 lbs.

BI-TRAN SIX operates as a single address binary parallel, magnitude and sign, arithmetic system. Each instruction consists of two consecutive 6-bit words, the first defining the operation to be performed, the second the operand address. Data consists of 5 bits representing magnitude and 1 bit for sign designation. A versatile instruction repertoire, consisting of 30 operation codes, permits the best use of the core storage.

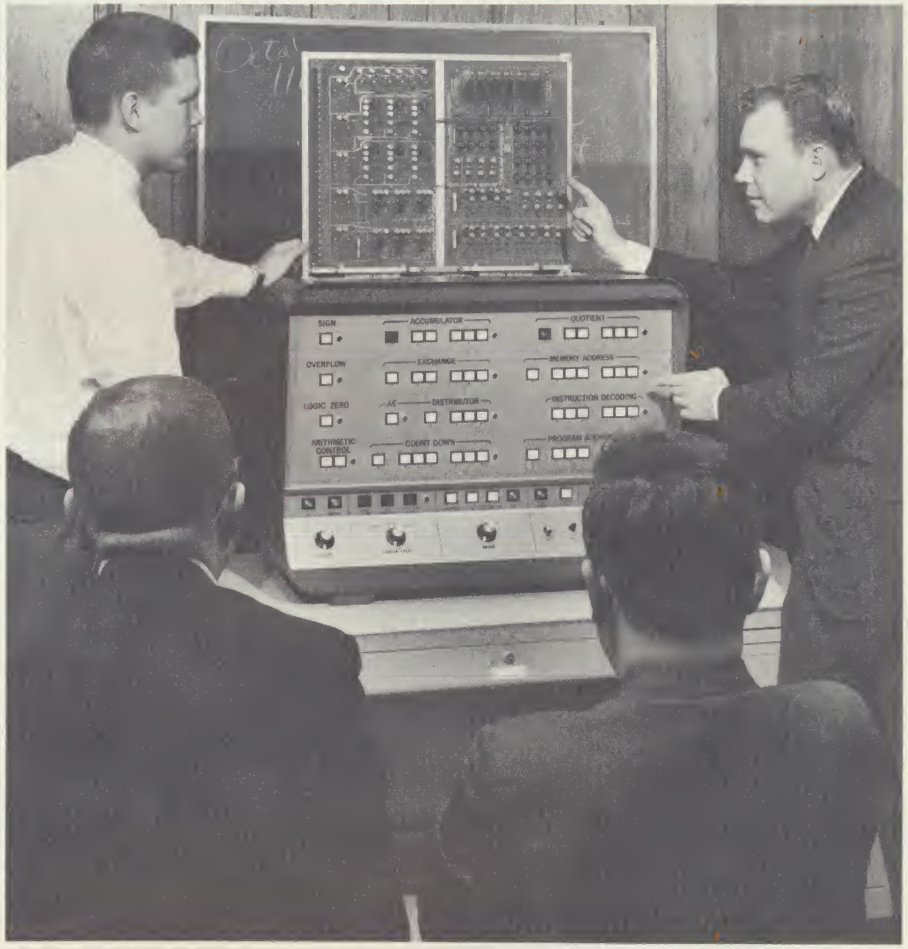


This simplified block diagram of the BI-TRAN SIX illustrates the easy-to-understand organization of the Digital Trainer.

The BI-TRAN SIX is a

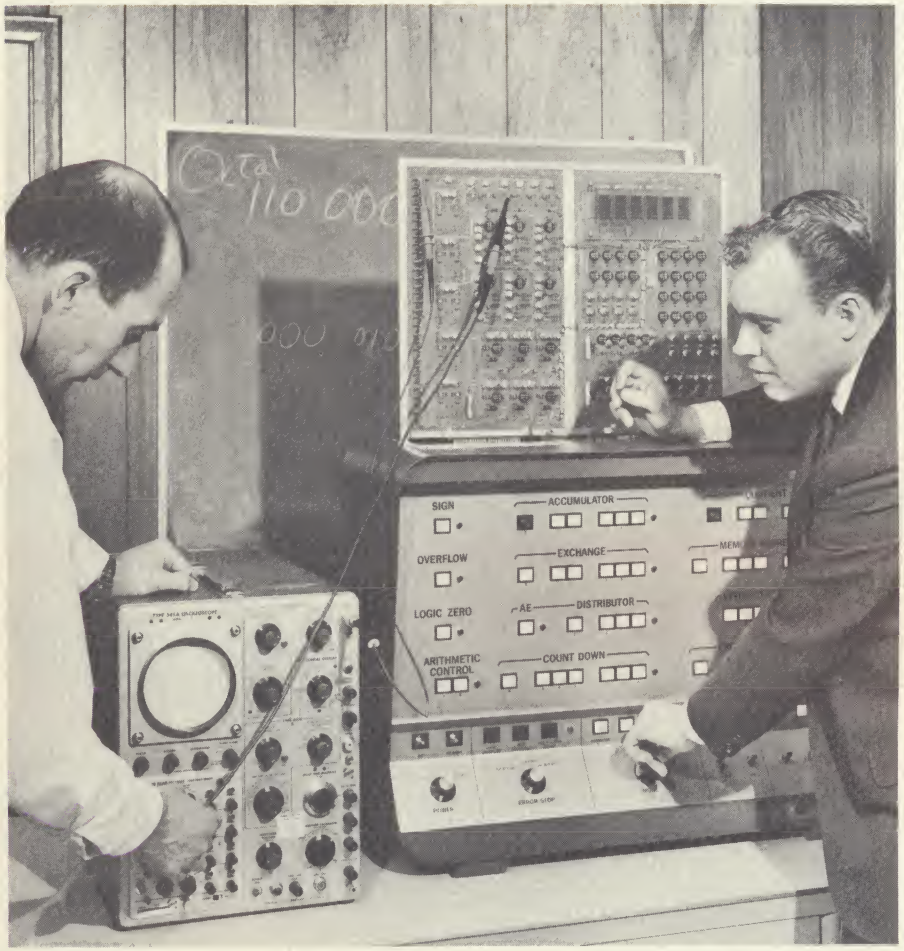


Big, over-size console makes classroom demonstrations really visible.



Large circuit boards extend while the unit is in operation for easy illustration of computer construction. All operating circuits are visible.

self-motivating, functional "textbook!"



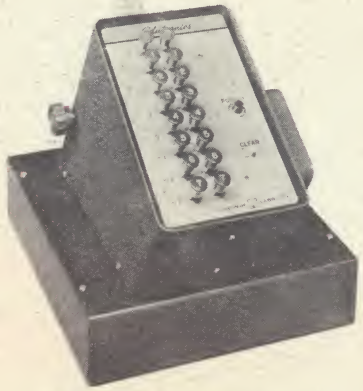
Waveform observation on an oscilloscope is simple with the BI-TRAN SIX.

Auxiliary equipment expands the teaching functions of the BI-TRAN SIX without straining equipment budgets.

Features

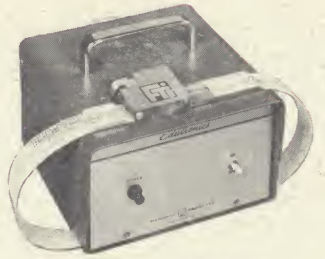
- A complete operating computer in miniature (128 words of 6 bits each)
- Lightweight and portable (weighs 98 pounds)
- Latest electronic circuit techniques used (all solid-state components)
- Coincident-current ferrite core memory (all words addressable)
- Instruction repertoire has 30 versatile instructions
- Indicator lights show operation of all registers (panel color-coded for quick comprehension)
- A one-to-one correspondence exists between the logic diagrams and the logic circuit boards
- Circuit boards extend while trainer is in operation for logic instruction
- Operates on standard 110-volt house current
- Safe (exposed circuits have maximum of 10 volts)
- Rapid maintenance service available (extra-high quality components are practically trouble-free)
- Available auxiliary units allow course expansion to cover a great variety of data processing instruction
- Operation and service manual, teacher's orientation manual, student workbooks, combined with the BI-TRAN SIX provide a complete course in computer education

Auxiliary equipment is available at prices meant to meet school budgetary requirements

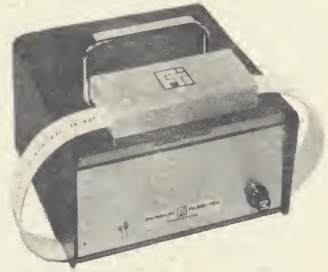


Off-line paper-tape punch

(octal-to-binary manual input keyboard not illustrated)



Paper-tape reader



Paper-tape strip printer

For more information on how you can have a BI-TRAN SIX for your curriculum, call, write or wire Richard C. McDonald at Fabri-Tek Educational Services Department, 1201 E. Lake St., Hopkins, Minn. 55343, Phone 935-1800 (area code 612). TWX: 612-292-4161.

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